

ALTERATION PRODUCTS AND SECONDARY MINERALS IN MARTIAN METEORITE

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The martian meteorites contain alteration products and secondary minerals that are a critical part of understanding their near-surface histories on both Mars and Earth. In some martian meteorites, suspected martian (pre-terrestrial) alteration products can be distinguished from terrestrial weathering effects [*e.g.*, 1-5]. Using scanning electron microscopy (SEM), field emission SEM (FE-SEM), transmission electron microscopy (TEM), and energy dispersive X-ray analysis (EDS), we are studying natural fracture surfaces of ALH84001 chips, including samples from both the interior and the exterior of the meteorite. Exterior samples include fusion crust surfaces, which are important in determining the extent of terrestrial weathering of meteorites. The focus of this study is weathering features and secondary minerals other than the distinctive carbonate globules that continue to be studied by many researchers.

Both the interior and the fusion crust of ALH84001 generally show very little evidence of terrestrial weathering. In [1, 6], we reported the presence of traces of typical Antarctic secondary minerals (Ca sulfate, Mg sulfate, NaCl, and SiO₂) on the fusion crust surface. The absence of these terrestrial minerals in the chips below the fusion crust surface is a good indicator of the lack of significant Antarctic alteration. We have now found one small occurrence of Ca sulfate slightly (~200 µm) below the fusion crust surface (Fig. 1). It is most likely of terrestrial origin because no Ca sulfate has been identified in interior samples. Another weathering feature not previously described is shown in Fig. 2. It consists of amorphous-looking carbon-rich material (not carbonate) partly filling a vug in the fusion crust. Traces of this carbon-rich material are found both on and near the fusion crust (*e.g.*, Fig. 1). More work is needed to determine if it is identifiable in interior samples with the SEM. Similar carbon-rich material was found on the fusion crust of Chassigny [2].

Evidence of alteration in the interior of ALH84001 consists mostly of pitted carbonate globule surfaces, etched silicates (mostly pyroxene), and traces of smectite-type clay associated with pyroxene [1, 6]. In addition to the carbonate globules, the interior contains traces of another type of Mg car-

bonate, as reported in [6]. This Mg carbonate (Fig. 3) has a distinct bladed morphology which is different from that of typical ALH84001 carbonate globules, and also has a different composition (higher O, no minor elements). It is probably secondary to the globule carbonate. This O-rich carbonate is found in the interior of the meteorite and within a few hundred micrometers of the fusion crust surface but it has not been found on the fusion crust itself. In [1] we reported that Fe sulfates were present in the interior of ALH84001. It is not clear, however, that they are actually sulfates because the amount of oxygen present is not well defined; TEM and diffraction work still need to be done. Examples of these Fe-, S-rich occurrences are shown in Figs. 4-6. Figure 4 is a backscattered electron image of a typical occurrence (the brightest patches with fine-grained granular to fibrous textures are the Fe-, S-rich phase, the smoother medium gray grains are chromites, and the dark gray masses are silicates). The Fe-, S-rich material is commonly found in clusters closely associated with chromite grains. The equant occurrence in Figure 5 appears to be a partly weathered equant pyrite grain. EDS indicates that the proportion of S to Fe decreases with increased alteration (Fig. 6).

It is clear that the interior of the ALH84001 meteorite has interacted with aqueous fluids but the fluids are not obviously the same as those that deposited salts on the fusion crust. Further studies of these types of features may allow us to determine where they originated and how they formed. It may also be possible to use mineralogical and textural evidence of the degree of terrestrial weathering to help determine the amount of terrestrial biological contamination. Distinctions between terrestrial and pre-terrestrial weathering effects should prove to be very useful in determining the origins of possible biogenic features [7] in the martian meteorites.

References:

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